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The Effects of Observers’ Expectations and the Probability of a Change Occurring on Change Detection Performance

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by

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This thesis was prepared under the direction of the candidate's thesis committee chair, Shawn Doherty, Ph.D., Department of Human Factors & Systems, and has been approved by the members of the thesis committee. It was submitted to the Department of Human Factors & Systems and has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Human Factors & Systems.

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Abstract

The change probability effect is a term coined by Beck et al. (2004) and it suggests that changes that are expected or "probable" are detected more easily than changes that are unexpected or "improbable". This research study investigates the change probability effect and the differences between observers who are looking for changes and those who are unaware that changes may exist. The results suggest that observers who are not expecting a change to occur are more likely to detect an improbable change than a probable change. The findings from this study have real world applications and also have implications for change blindness research studies.

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Introduction

Our ability to detect changes in our environment is an important part of everyday life. A task such as driving requires us to constantly monitor our surroundings in order to detect changes such as a traffic light changing color, a car pulling out in front of us, or sirens blaring in the distance. We are often able to easily identify these changes and act accordingly. However, research has shown that sometimes we do have difficulty detecting these changes in our environment, even when they are directly in front of us. There is a large body of research on how humans detect changes that occur around us. However, there is still much to be learned about what types of changes we are most likely to detect and those that go undetected. There can be some benefits to not detecting changes. For example, if we did detect all of the changes that occur around us then we would have less attention to focus on other more important tasks. While not detecting changes can sometimes be beneficial, there are other times when very important changes go undetected and results in negative consequences.

The term change detection refers to when an observer correctly detects changes. Often the term change blindness is used instead of change detection because researchers are generally more interested in the types of changes that observers fail to notice rather than those that are detected (Simons, 2000). By tracking what types of changes often go unnoticed, researchers can better understand how people carry out visual searches and interpret scenes (Aginsky & Tarr, 2000; Henderson & Hollingworth, 1999).

One important aspect of change blindness studies is that there are many different manipulations that can be made, which allows researchers to study many domains and phenomena. While change blindness can be used to study broad areas of research, it can also be used to study more specific tasks. By investigating what types of changes are more likely to detected or undetected, researchers are able to improve the design of technology, complex systems, and the process in which tasks are completed. A few examples of the domains that have been studied by change blindness include: driving a car (Richard et al., 2002; Wallis & Bülthoff, 2000) flying a plane (Haines, 1991), monitoring a nuclear power plant (Durlach, 2004), screening passengers at an airport (Wolfe, Horowitz, & Kenner, 2005), and eye witness testimonies (Davies & Hine, 2007).

While change blindness studies have allowed researchers to better understand where and how observers detect changes in visual scenes, there are still areas that need more research. One change blindness area that requires more research is how changes are detected when an observer is not actively looking for a change. This is an important area to study since often observers are not expecting or looking for changes during everyday tasks. While this has been studied in the past (Levin & Simons, 1997), many of the research studies have not compared the results of observers who are looking for changes and those who are not (Davies & Hine, 2007). Some studies have made such a comparison (Beck, Levin, & Angelone, 2007a), however, the observers who were not looking for a change were given a task that did not allow them to view the scene in a similar manner as those who were looking for changes. Because of these issues, few conclusions can be made on the difference in change detection performance for observers looking for changes and those who are not. Therefore, more research is needed in order to better understand what types of changes and stimuli are most likely to go undetected when observers are not expecting a change to occur.

Another area of change blindness that needs more research is how unusual changes are perceived and detected by observers. This topic is important to study since it is common for change blindness studies to include changes that can be perceived as unusual and abnormal. For example, a study investigating change detection for traffic scenes may include a traffic light that is present in one image and disappears in the second image. This could be considered an unusual change since it is extremely unlikely that a traffic light would disappear between the glances of an observer in the natural world. It is likely that change detection performance for this unusual change would differ from a more common change such as a traffic light turning from red to green. This idea that the probability of a change occurring can have an impact on change detection performance needs more research since it is a topic that has received little research in the past.

Types of change blindness studies

The most common type of change blindness study involves image comparison (Simons, 2000). Image comparison studies are when observers are shown two images and their goal is to find differences between them. The two most common ways this is done is by the "flicker" paradigm or the "one shot" paradigm (Simons, 2000). In both of these paradigms, the observer is presented with an original image, some type of visual disruption, and then a modified image. The images used in these paradigms can be composed of shapes, computer generated scenes, photographs, or other similar stimuli. The changes that occur can also vary, with the most common and perhaps simplest being the addition or deletion of an object. Other changes can be made to the properties of an item, such as the objects orientation, size, shape, or color (Rensink, 2002). The main difference between these two paradigms is that the flicker paradigm continuously cycles between these images, while the one-shot paradigm only presents each image one time.

Images shown in the flicker paradigm are typically presented between 200 and 600 ms (Rensink, 2002). Some type of visual disruption is presented between the two images in order to mask the change that occur. The most common visual disruption, also known as an interstimulus interval (ISI), is a blank screen that is presented between the two images. A blank screen ISI typically appears for around 80 – 500ms with longer durations resulting in a decrease of change detection performance (Pashler, 1988; Rensink, O'Regan, & Clark, 2000).

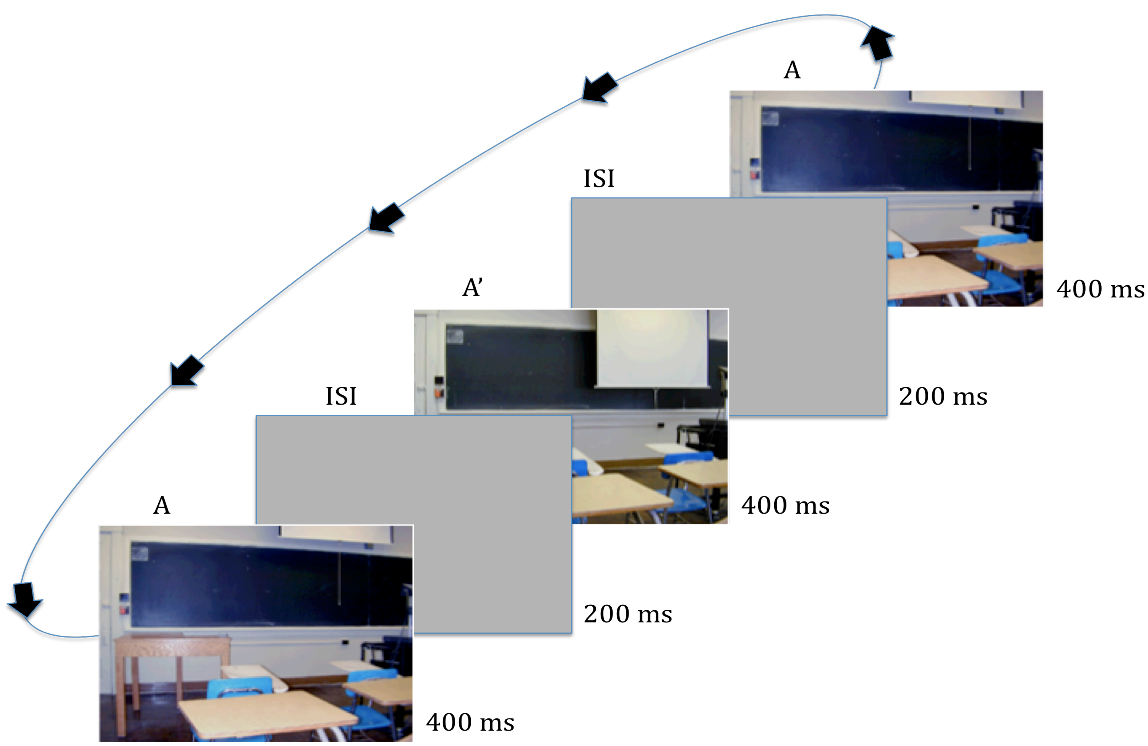


Fig. 1. An example of the flicker paradigm. The prechange scene (A) is presented and then a visual disruption (ISI) appears, followed by the postchange scene (A'). This cycle continues until the observer either detects the change or a time limit is reached.

Performance in change blindness studies that use the flicker paradigm are usually measured by accuracy and response time. Response time can be measured by the amount of time and/or alterations needed in order to detect a change. Typically multiple alterations are needed in order for an observer to detect a change. It is also not unusual for changes to go undetected for an entire minute of alterations (Simons, 2000). Because it can take a while for changes to be detected, it is common for a time limit to be included, which is typically around 60 s (Rensink, O'Regan, & Clark, 1997).

The flicker paradigm can be beneficial for studying where observers are looking while viewing different scenes. This is because the continual cycling of the images gives participants many opportunities to detect changes. Therefore, changes that are detected relatively quickly are believed to be focused on earlier and more often than changes that take more time to detect. For example, Rensink et al. (1997) found that changes made to objects in the "centre of interest" were detected more easily than peripheral or "marginal interest" changes. The authors believe that change detection performance was better for changes that involved objects of central interest because they were either focused on earlier or more often.

The one-shot paradigm is essentially a simplified version of the flicker paradigm in which the images do not repeat. The original image is typically presented between 4 and 10 s. An ISI, which is usually a blank screen, is then presented for around 80 – 500ms. After the ISI is presented, the modified image appears. The duration of the modified image will sometimes appear for a given amount of time, however, it is also common for the modified image to be presented until the observer responds to whether or not they identified the change. Performance in the one-shot paradigm is typically measured by accuracy, although response time is sometimes measured as well (Rensink, 2002).

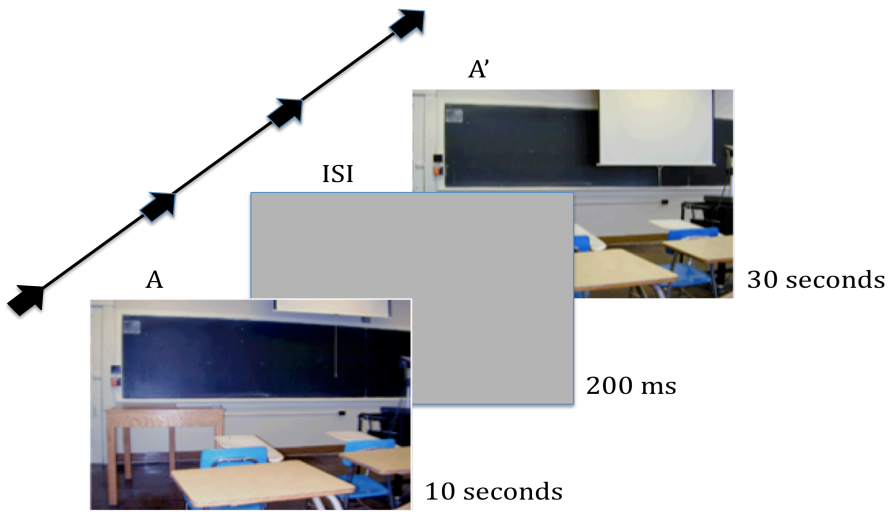


Fig. 2. An example of the one-shot paradigm. The prechange scene (A) is presented and then a visual disruption (ISI) appears, followed by the postchange scene (A'). After the postchange scene (A') appears, the observer responds to whether or not they detected a change.

It can be argued that the one-shot paradigm can be more beneficial than the flicker paradigm when studying the short-term memory of an observer. Because the one-shot paradigm gives the observer only one opportunity to detect a change, successful change detection suggests that the observer retained the encoded prechange information and then compared this information with the postchange stimuli. Therefore, the one shot paradigm can be more useful than the flicker paradigm for studying visual short-term memory.

In many circumstances studying short-term memory is more beneficial than studying the scan patterns of an observer. For example, pilots should always be aware of their speed, altitude, and heading. While studying the scanning pattern of these instruments is important, it is also important to understand how this information is encoded and retrieved from short-term memory. By using the one-shot paradigm, a researcher can investigate how well a pilot is able to encode and retrieve this information by looking at what changes are likely or unlikely to be detected.

Both the flicker paradigm and the one-shot paradigm have unique advantages and disadvantages associated with them. A researcher may choose one paradigm over the other depending on what is being researched. Both paradigms have been shown to be effective in producing and studying change blindness.

Why does change blindness exist?

There appears to be no single reason why change blindness occurs. It is likely that it occurs differently for people and the type of scene or environment that is being viewed. The most widely accepted argument for why change blindness exists is that focused attention is needed to detect a change and only so many objects can be focused on at one time (Rensink, 2002). Because the images used in change blindness studies usually contain a large number of items and features, it is impossible to focus on every object or item in a scene at once. Research suggests that people are only able to simultaneously monitor four to five items in a scene (Rensink, 2000). Because of the complexity of scenes that are used to study change blindness, it usually takes multiple eye movements for an observer to detect a change.

It can also be argued that change blindness exists because of the ISI presented to the observer. In natural viewing conditions, there is usually some type of motion that corresponds with a change (Klein, Kingstone, & Pontefract, 1992). This motion will often alert the observer and allows them to use focused attention to identify and respond to the change if needed. However, the purpose of an ISI in change blindness studies is to mask this movement and thus not alert the observer of the change.

It is believed that successful change detection requires a representation of the scene before the change and then a comparison of that representation after the change occurs (Simons & Ambinder, 2005). It appears that change blindness can result from a failure from either of these stages or a combination of them both (Hollingworth & Henderson, 2002; Mitroff, Simons, & Levin, 2004; Rensink, et al., 1997) However, it has been argued that observers who are not aware that changes may occur are more likely to miss a change because they do not think to compare the two scenes (Levin & Simons, 1997). In one study conducted by Simons, Chabris, Schnur, and Levin (2002), an experimenter carrying a red and white striped basketball asked a pedestrian for directions to the campus gymnasium. While the pedestrian provided directions, a small group of people walked by and the experimenter surreptitiously handed off the basketball. When the pedestrians were questioned about the occurrence, most of them did not report noticing the change. However, when they were asked more directed questions about what the experimenter was carrying, most of the pedestrians were able to recall the basketball and could even remember that it had red and white stripes. It can be assumed that the pedestrians in this study encoded the information properly, but that they did not think to compare the stimuli. The results from this study suggest that changes may go undetected because our visual system assumes an unchanging world (Simons & Levin, 1998). In other words, because at any given time there is too much stimuli around us to continuously monitor, we assume that stimuli that is not expected to change will not change from one glance to the next without some type of movement involved.

Expectations of the observer

Research has continually suggested that the expectations of an observer can greatly affect change detection performance (Beck et al., 2007a; Davies & Hine, 2007; Pearson & Schaefer, 2005; Wolfe, et al., 2005). The expectations of an observer can be classified as being either intentional or incidental. Intentional change blindness studies are when the observer knows that changes may occur and they actively look for those changes while incidental change blindness studies are ones in which the observer does not know that changes may occur.

Participants in an incidental change blindness study are usually given some other task as their primary responsibility. This task could be studying the image for later recall (Pashler, 1988) or searching for a specific non-target item in the scene (Beck et al., 2007a). Incidental change blindness studies can be very useful and it can be argued that they more closely resemble natural viewing conditions than intentional change blindness tasks. This is because in our everyday life we do not usually view and encode scenes with the goal in mind of detecting changes. Instead, we tend to only look for changes when we are completing a task that requires us to look for changes. Even then, it is likely that we are only looking for specific types of changes that are likely to occur. For example, when a driver is stopped at a traffic light, it is not likely that he or she will be looking for random changes, but instead only be searching for changes that are related to the task of driving such as the flow of traffic and the status of the traffic light. Therefore, it can be beneficial to research differences in expectations of observers along with what types of changes are more likely to go undetected.

While incidental change blindness studies can be very useful, there are also some issues with conducting this type of study. One difficulty is that participants can only complete one trial. This is because once a participant detects a change or is asked if one has occurred, the participant will be aware that a change can occur and will begin looking for changes in later trials. Because only one trial can be used for each participant, individual trials cannot be compared between each participant. This means that a large amount of participants are needed for the study. Another major issue is that the expectations and motivation will likely differ for each participant. For example, some participants may expect a change to occur compared to other participants even though they were not instructed to look for changes.

When conducting an incidental change blindness study, it is important that the participants view and encode the stimuli while being unaware that changes may occur. To ensure that the participants encode the stimuli, researchers will often instruct the participants to complete a task such as searching the image for a particular object or viewing an image for later recall. While a secondary task does distract the observer from looking for changes, it can also make it difficult to compare the incidental change detection performance with performance of an intentional change detection control condition. This is because the secondary task can change the way in which an observer encodes and compares stimuli. Therefore, it is very important that a secondary task of the incidental condition allows the observers to encode the information in a similar manner as the intentional condition.

One incidental change blindness study conducted by Beck et al. (2007a) had participants search for a pair of eyeglasses in a scene that contained 4, 7, or 10 objects. After viewing the scene for two seconds, a new image appeared and one of the objects was replaced by an object of similar size. None of the scenes included a pair of eyeglasses; therefore, the participants completed an exhaustive search of the scene. An intentional control group also completed the same task and was told that a change would occur in the scene. The results showed that the intentional group detected the change more often than the incidental group and the difference in performance increased as the number of objects in the scene increased.

Based on the data from Beck et al. (2007a), it appears that knowing that a change will occur increases change detection performance. The authors speculate this is because observers who are expecting a change to occur can maximize the use of their short-term memory by properly encoding and retrieving the stimuli. In other words, the observers realize an effective strategy for detecting a change is to try and remember what the contents of a scene are and then look for an item that they do not remember being in the scene. It is likely that the observers in the intentional group were less likely to detect the change when more items were in the scene because they could not keep all of these items in their short-term memory long enough to make the comparison. However, they were not as affected as the incidental condition by the increase of items in the scene because they were still able to remember and compare many of the items.

The observers who were not expecting a change to occur were less likely to detect a change because they did not try to remember all of the items in the scene. It is likely that when they were able to detect a change it was because they happened to be paying attention to some aspect of the object that changed. When more items were included in the scene, the probability of looking at the item that changed decreased and therefore change detection performance decreased as well.

The research done by Beck et al. (2007a) is interesting for the current study because it one of a few that compares performance between intentional and incidental change detection tasks. However, there are some important differences between the two groups that should be pointed out. The intentional group was instructed that a change will occur and so it is likely that participants encoded as much possible information about the objects in the scene for the two seconds that the original image was shown. However, the incidental group was only searching for a specific object in a scene. It is likely that the observers did not encode as much information about each object and simply decided if it was or was not a pair of eyeglasses. Since it is likely that the two groups differed in how they encoded the information, the expectations of the observer may have not been responsible for the differences in change detection performance. Therefore, research investigating the differences between incidental and intentional change blindness needs to ensure that the encoding of stimuli is as similar as possible for both conditions.

Research done by Davies and Hine (2007) also suggests that encoding differences can affect performance for incidental change detection. These researchers created a two-minute video clip of a home invasion in which the identity of the burglar changed after one minute. Half of the participants were instructed to carefully watch the video because they were going to be questioned about it later. The other participants were only instructed to watch the video, which they were told was about the dangers of home invasions. The results showed that 65% of participants told to carefully watch the video detected the change while only 12.5% of participants who were only instructed to view the video detected the change. This research done by Davies and Hine (2007) is important because it shows how change detection performance can be affected by the way the instructions are given to participants. Both of the groups in this study were not expecting a change to occur, but the ones told to carefully watch the video were more likely to detect the change. Therefore, it can be assumed that the different instructions caused the participants to encode the stimuli in a different manner. Because of this, it is very important that when intentional and incidental change blindness performance are compared, that the two groups encode the information as similarly as possible. This is so the difference in change detection performance can be attributed to one group being unaware that changes may occur rather than a difference of encoding between the two groups.

Levin and Simons (1997) also studied incidental change detection using a video clip. The video clip used in their study involved different actors having a conversation while nine different changes occurred. These changes occurred when the video focused on another part of the scene and the objects either disappeared or were replaced by different objects. Participants were instructed to pay close attention to the video but they were not instructed of the changes. Even though some of these items came into direct contact with the actors, almost all of the changes went undetected. In fact, of the 10 participants who viewed the video, only one of them noticed any of the changes and only vaguely described the change as “the way the people were sitting” (Levin & Simons, 1997, p. 502). The participants were then shown the video again and asked to look for the changes they had missed. They were only able to detect an average of two of the nine changes. This research also suggests that performance is higher in intentional change detection than incidental change detection. However, there were no control groups that only viewed the video while actively looking for changes. Therefore, the difference in performance could be from learning effects and not from actively looking for changes.

While the available research suggests that the expectations of an observer does influence change detection performance, additional research is needed in order to better understand this relationship. Specifically, research needs to investigate differences in change detection performance for incidental observers and intentional observers. This research should also attempt to create similar levels of encoding for all of the participants in order to insure that the differences in performance can be attributed to the expectations of the observer and not to differences in encoding.

Change Probability Effect

Another area of change blindness that needs more research is how the probability of a change occurring can influence change detection. While there is some available research on this concept, it has received relatively little attention among researchers. The first to research this effect was Beck, Angelone, and Levin (2004) who found that participants were able to detect probable changes more often than improbable changes. The authors defined a probable change as one that is likely to occur in a natural setting. It is also important to note that the authors were referring to the probability of a particular change occurring, and not the probability that a particular object will change. For example, a lamp changing from off to on would be classified as a probable change, while a blue lamp changing into a red lamp would be classified as an improbable change.

All of the changes used in Beck et al. (2004) were classified being probable or improbable. Four raters were instructed to rate “the likelihood of each change occurring from one glance to the next in their everyday visual environment” (Beck et al., 2004, p. 780). There were 10 different prechange images and 20 postchange images used in the study. Each prechange image had two corresponding postchange images that contained either a probable or improbable change. The participants in the study were divided into an intentional condition and a “story telling” condition. Participants in the intentional condition were instructed to look for changes in all trials. Participants in the story telling condition were instructed to imagine they were authors trying to think of a story for a new book and to think of a short story for each scene. They were also told that on about one third of the trials a brief blank screen would appear followed by a second image would that contained some type of change. They were instructed to indicate what had changed and what the object looked like in the previous image. The results from this study showed that change detection performance was better for probable changes in both the intentional condition and the story telling condition.

Later research by Beck, Peterson, and Angelone (2007b) further investigated the change probability effect. The researchers were specifically interested in whether observers are biased towards processing probable changes in the encoding stage or the retrieval and comparison stage. The researchers used long-term memory tests to investigate this issue. Long-term memory tests of the images were given after the participants completed the change blindness tasks. The participants were shown the prechange scene and postchange scene that included either a probable or improbable change. In each scene a green arrow pointed to where the scenes differed so that the participant would know where to focus their attention. The postchange scene that was shown to the participants was always the postchange scene that had not been shown in the previous change blindness task meaning that the prechange scene was always the correct answer. The researchers argued that if the participants were more likely to encode probable prechange aspects of a scene than they would be more likely to respond that they had not seen the improbable postchange image than the probable postchange image. However, the participants were able to correctly choose the prechange scene 79% of the time and were not significantly more likely to choose the improbable postchange scene than the probable postchange scene. This finding suggests that the participants were not any more biased towards processing probable aspects of a scene than improbable aspects of a scene.

Eye tracking data also showed that observers were not more likely to fixate on stimuli related to probable changes than improbable changes. Because encoding visual information requires fixation, this also implies that the participants were not biased towards encoding probable changes. Therefore, the results from the long-term memory tests and the eye tracking data suggests that observers are not more likely to encode aspects of a scene that they perceive as likely to change.

The findings from Beck et al. (2004) suggest that observers are biased towards processing stimuli related to probable changes and the findings from Beck et al. (2007b) suggest that this bias exists in the retrieval stage of change detection. Both of these studies on the change probability effect have helped researchers better understand how observers encode and retrieve stimuli while looking for changes. However, more research is needed in order to better understand change blindness and the change probability effect. Specifically, research needs to be conducted on how observers detect probable and improbable changes when they are not actively looking for changes in their environment.

Observers' expectations and the change probability effect

While research has suggested that both the expectations and the probability of a change occurring can influence change detection performance, the interaction between these two variables has received attention yet little scientific research. Many early incidental change blindness studies have used unusual events and changes that are unlikely to occur in natural environments (Grimes, 1996; Levin & Simons, 1997; Simons & Chabris, 1999). Some of these unusual stimuli include two cowboys switching heads (Grimes, 1996), jet engines disappearing (Rensink et al., 1997), and even a person in a gorilla suit walking across a scene in a video (Simons & Chabris, 1999). However, none of these studies compared change detection performance between probable and improbable changes and rarely compared performance between intentional and incidental change detection.

The available research has only partially investigated the relationship of observers' expectations and the probability of a change occurring. Research done by Beck et al. (2004) studied how expectancies of observers can influence change detection performance for probable changes. The researchers found that participants in a divided attention task performed worse than participants in an intentional change detection task. They also did not find an interaction between the probability of a change occurring and the expectations of the observers because change detection performance was superior for probable changes than improbable changes for both groups. However, the participants in the divided attention task were still aware that changes may occur during some trials. Therefore, they still had some expectations that a change may occur. It can be argued that the second task only reduced the amount of attention that the participants devoted to detecting changes instead of completely altering how they viewed the images. Because all of the participants in Beck et al. (2004) were aware that changes could occur, the findings from this study do not necessarily suggest that an interaction does not exist between an observers expectations' and the probability of a change occurring.

The Present Experiment

The primary goal of this research is to replicate the change probability effect and to investigate if it exists when observers are not actively looking for changes. The study has three hypotheses. The first hypothesis is that change detection performance for the intentional condition will be superior compared to the incidental condition. The second hypothesis is that probable changes will be detected more often than improbable changes. The third hypothesis is that an interaction will exist between the expectations and the type of change that occurs. Specifically, participants in the intentional condition should detect probable changes more often than improbable changes, however, there will not be a significant difference in change detection for probable and improbable changes for the incidental condition. This is likely to be the case because the participants who are looking for changes will encode and retrieve stimuli in a way to increase change detection, which will result in detecting probable changes more often. However, the incidental participants will not encode and retrieve stimuli in this manner and therefore will be unaffected by probable and improbable changes.

Method

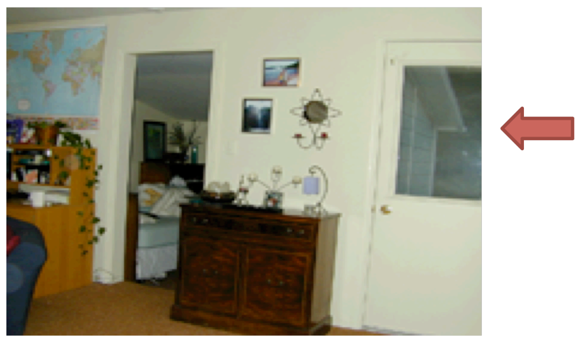
Participants

A total of 153 psychology students were tested during seven regularly scheduled classes. Because a rather large number of participants was needed for the study, students were tested from two separate colleges. Overall, there were 88 male participants and 65 female participants. The sex of the participants varied by school, with 82.0% of the participants from one school being male and 18% being female. From the other school, 71.4% of the participants were female and 28.6% were male. The age of the participants from both schools ranged from 18 – 52, with (M = 20.4). The age of the participants was also slightly different between schools with (M = 21.2) for one school and (M = 19.5) for the other school.

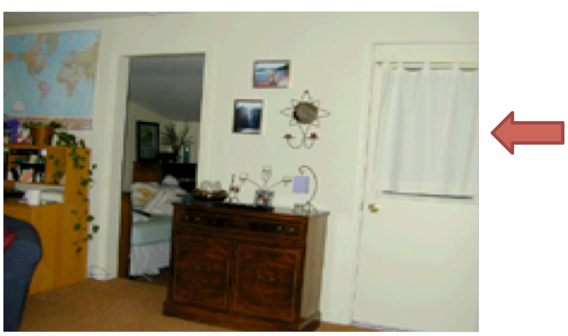
Materials

The images used in the study were taken from Beck et al. (2004) and Beck et al. (2007a). Both studies used the same 10 image sets that included a prechange scene, a corresponding probable postchange scene, and a corresponding improbable postchange scene. Each of the probable and improbable changes were rated by four raters on their probability of occurring from one glance to the next in their everyday visual environment. The images were also rated on other factors including the centrality of the object, the typicality of the change in relation to the scenes schema, and the physical size of the changes by measuring pixel changes between the two scenes.

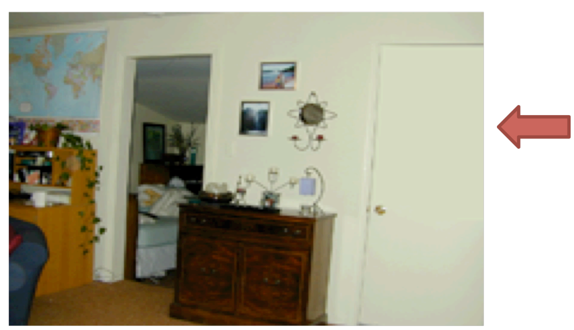
Because the study involved single trial learning, only one set of the original 10 images was used. The image set was chosen because both the probable and improbable changes occurred to the same object, were in the same location of the scene, and were relatively of the same size. The image set used in the study depicted a living room where both the probable and improbable changes occur to a door located in the right side of the image. The prechange scene showed a door that contains a window in the upper half. In the probable postchange scene a curtain covered up the window and in the improbable postchange scene the door did not have a window.



Prechange Scene



Probable Postchange Scene



Improbable Postchange Scene

Fig. 3. The image set that is to be used in the experiment. The prechange scene is paired with either the probable postchange scene (window is covered by a curtain) or the improbable postchange scene (window disappears).

Design

This study had two independent variables that included the expectations of the observers and the probability of the change occurring. The only dependent variable in the study was whether or not the participant was able to detect the change that occurred.

Procedure

In total, there were seven different classes that were tested. Four of these classes were tested as intentional and the other three were incidental. In all trials, the prechange image was displayed for 10 s, followed by an ISI for 1 s and then the postchange object for 10 s. After the postchange object disappeared, a screen appeared instructing the participants to write down the object that changed if they had detected it. The experimenter also read these instructions as soon as the screen appeared.

Participants in the intentional condition were told that their task was to detect changes in images of everyday scenes. They were told that an image was going to appear on the projection screen and that they should study the contents of the scene. They were also told that at some point an object in the scene would change and their task was to try and detect the object that changed.

The participants in the incidental condition were told that would be participating in a study that investigated how well observers are able to remember contents of an everyday scene. They were instructed that an image would appear on the projection screen and their task was to remember the contents of the scene. They were also instructed that they would be questioned about their memory of the scene after the image disappeared.

In all trials the same prechange image was shown to the participants. However, half of the participants from each condition were shown the probable postchange scene and the other half of participants were shown the improbable postchange scene. Once the participant responded to whether or not they detected the change, they were asked to choose a description of their familiarity with change blindness from a five point Likert scale. The participants were also instructed to write down their seat location to see if the participants' viewing distance and angle affected change detection performance.

Results

Data were collected from a total of 153 participants, however, some data responses from each condition were randomly selected to be removed in order to have equal sample sizes in all conditions. Overall, 33 data responses were removed, with 10 coming from the intentional probable condition, 16 from the intentional improbable condition, 6 from incidental probable, and 1 from incidental improbable.

Responses were encoded as being correct if the participant was able to list the object that had changed. While all of the participants were asked to give a description of what the object looked like before the change, some participants did not include this description or included a wrong description of the prechange object. However, these responses were still encoded as being correct since the participant was able to identify the object that changed.

Overall, participants were able to correctly detect the change over half of the time (M = 51.7%). On a few occasions the participants responded with the wrong object (M = 3.3%) and on the remaining trials the participants did not list any objects as changing (M

= 45.0%). Participants in the intentional condition (*M* = 61.7%) were able to correctly detect the change more often than those in the incidental condition (*M* = 41.7%). A chi-square analysis indicated that this difference was significant (p = .028). These results support the first hypothesis.

Table 1. Participants' response for change detection in each condition.

	Change Detection Performance		
Condition	Correct Response	No Response	Incorrect Response
Intentional Probable	60.0%	36.7%	3.3%
Intentional Improbable	63.3%	30.0%	6.7%
Incidental Probable	26.7%	30.0%	3.3%
Incidental Improbable	56.7%	43.4%	0.0%

A chi-square analysis indicated that overall, the difference between the detection of probable changes (*M* = 43.3%) and improbable changes (*M* = 60.0%) was not significant (p = .068). The results indicated that the intentional condition detected improbable changes (*M* = 63.3%) slightly more often than probable changes (*M* = 60.0%). These findings do not support the second hypothesis of this study and also goes against previous research from Beck et al. (2004) and Beck et al. (2007a). However, it is important to note that on 11 intentional change detection trials where the improbable change was shown, the participants responded that the door had closed instead of responding that the window had disappeared. On these trials, the responses were still encoded as being correct since they involved the object that had changed. However, it can be argued that a door changing from opened to closed would be classified as a probable change. So, even though these participants detected an improbable change, it is likely that they were influenced by their perceived likelihood that a particular change occurred. Therefore, it is likely that the intentional condition was affected by the change probability effect even though the data suggest otherwise.

The results also indicated that the incidental participants were able to detect the improbable change (M = 56.7%) more than the probable change (M = 26.7%). A chi-square analysis indicated that this difference was significant (p = .018).

These findings do not support the third hypothesis, which states that the incidental condition would not be affected by the probability of a change occurring. It is also important to note that only two participants in the incidental improbable condition responded that the door went from open to closed.

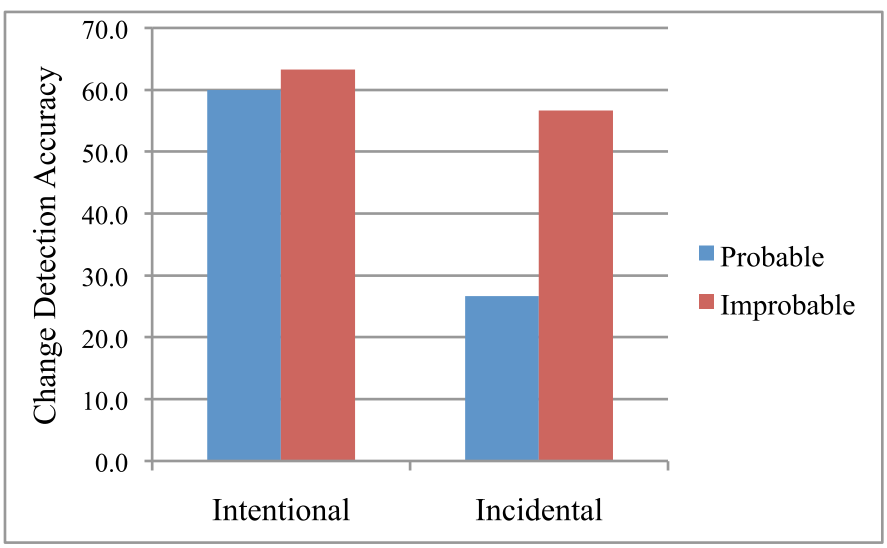


Fig. 4. Performance in intentional and incidental change detection for probable and improbable changes.

A chi-square analysis also indicated that overall, participants who were more familiar with change blindness by self-report were not significantly better at detecting the changes ($p = .292$). Change detection did seem to be slightly affected by participants' familiarity of change blindness in the incidental condition, but a chi-square analysis indicated that the difference was not significant ($p = .073$). Data responses were grouped together for participants that responded that they had never heard of change blindness and participants that responded that the term sounded familiar. This group was then compared to participants who responded that they were familiar with change blindness. A chi-square analysis indicated that change detection performance did not differ between the two groups ($p = .081$).

A chi-square analysis also indicated that the difference in change detection was not significantly affected by how far away from the presentation the participant sat ($p = .136$). However, the aisle that the participant was sitting in was found to significantly affect change detection performance ($p = .018$). The aisles that had the worst overall change detection performance were those on the far left side of the classroom ($M = 28.1\%$). One possible explanation for this finding is that the participants on the left side were not able to detect the change as often since both the probable and improbable changes were located on the right side of the screen. However, when data from the far left aisle were removed from analyses, a chi-square analysis indicated that change detection performance was still significantly affected by the probability of a change occurring for the participants in the incidental condition ($p = .037$).

Change detection performance did not seem to be affected by the school in which the participants' attended. A chi-square analysis indicated that the difference was not significant (p = .741).

Discussion

The results from this study suggest that participants who are aware that changes may occur are better able to detect changes than participants who are unaware that change may exist. This finding is supported by many other change blindness studies that compare performance for intentional and incidental change detection tasks. The change probability effect was not replicated as seen in the research by Beck et al. (2004) and Beck et al. (2007b). However, it is likely that this effect still played a role in change detection. This is because on 36.7% of the intentional trials where an improbable change was shown, the participants responded that the door went from being opened to closed. It can be argued that these participants were unable to encode a full representation of the object before the change occurred. On these trials, it is likely that the physical change of the stimuli directed the participants towards the change. It is also likely that the participants remember being able to see through the window to outside and so when they were instructed to write down what the object looked like before the change occurred, the most plausible explanation was that the door was open.

The results from this study also showed that change detection performance differed between probable and improbable changes in the incidental condition. There are several speculations as to why this could have occurred. The first and perhaps most likely reason that improbable changes were detected more easily in the incidental condition is because the improbable change was more likely to grab the attention of the participant. It is likely that once the change occurred, the improbable change was more likely to grab the participants' attention because this change was less likely to fit into their representation of the scene. For example, it is likely that most if not all of the participants had looked at the door and encoded the window into their memory. If the participants saw the probable change, they were likely to have looked at the window again, but this time curtains were covering up the window and so the change is not likely to be brought to their attention since the window is still present. However, if the participants saw the improbable change, they were likely to have looked at where the window was and this time the disappearance of the window may have grabbed their attention.

It is also likely that the difference in change detection performance for probable and improbable changes was not significant for the intentional condition because the improbable change did not grab their attention as much as it did for the incidental condition. This is likely because the intentional participants were expecting a change to occur. So, when they were looking for a change it is unlikely that probability of a change occurring altered their searching strategies. They simply looked for any and all types of changes, regardless of the probability of that change occurring.

Speculations can also be made as to why the incidental participants who viewed the improbable change were not as likely as the intentional participants to respond that the door changed from opened to closed. This can likely be explained because the incidental condition had a better representation of what the scene looked like before the change occurred because they were asked to remember the contents of the scene. On the other hand, it is possible that the intentional condition relied more on their visual system to detect a change than on their memory of the prechange scene. If the participants detected a change and could not remember exactly what the door looked like before the change, then they are likely to have responded that the door went from opened to closed because this is a plausible explanation as to why they remembered being able to see something outside in the prechange scene.

There are several limitations of this study that may have impacted the findings. One issue is that participants were tested in large groups so that enough participants would be included in the study. There are several ways in which this could have impacted the study. While the experimenter tried to keep the testing process equal for all trials, there were some differences that could not be controlled for such as the spatial layout of the classrooms, lighting, and seat location. Another issue is that all data were collected from only seven trials. So, if some type of distraction occurred in one of these trials then it could have affected change detection performance. It is also possible that some of the participants looked at the responses of the person sitting next to them and copied their response. While the experimenter did not witness this occurring, it is still possible that participants copied their responses from others.

While many of these factors may not have affected the findings, the participants' visual angle was found to significantly affect change detection performance. The lowest change detection performance was found on the far left side of the classroom with only 28.1% of changes being detected from participants sitting in this area.

While there may have been some negative effects of testing so many participants at once, one positive aspect of testing many participants at once is that many factors were the same for all of the participants of each trial. For example, all of the participants in each trial encountered the same lighting conditions, the same projection screen, and were given the exact same instructions. Because all of the participants were exposed to many of the same factors, these factors should not have affected change detection performance between the participants.

Another area of concern with this study is that only one image set was used. Most change blindness studies use many different images that include different types of changes. However, this study was unable to do so because it involved incidental change blindness, which meant the participants were only able to be tested once. Only using one image set makes it difficult to attribute the differences in change detection performance to the probability of a change occurring and not some other factor such as the difference in the physical properties of the changes. Change blindness studies usually use multiple images so that these other factors average out over many trials. For example, a probable change may have a larger change in one scene and then a smaller change in another. Over many trials these differences will cancel out and should not affect the results of the study. In the present study, care was taken in choosing the image set so that certain factors would not affect the results. For example, both the probable and improbable changes occurred to the same object, were of relatively the same size, and involved similar colors. While these factors should not have affected the results of this study, there are other factors that may have affected the results. One such possible factor is that the improbable change involved an object deletion (window disappearing) while the probable change involved an object addition (blinds appearing). Research suggests that object deletions are generally noticed more frequently than object additions (Mondy & Coltheart, 2000). However, this may not have affected the results of the study because many of the participants responded that the door closed rather than the window had disappeared. So, it appears that many of the participants encoded the view of outside rather than the actual window, which is why they were likely to respond that the door had closed. In both changes the view of outside can be classified as a deletion, therefore, the difference in change detection for object addition and deletion may have not have played a large role in change detection performance.

The results of this study suggest that change detection performance can be affected by the probability of a change occurring. These findings have real world implications for how observers detect changes and in how change blindness research should be conducted. One example in which this could apply to a real world situation is how doctors diagnose ailments of a patient. Doctors have to look for certain symptoms and changes in order to diagnose and treat patients. It is likely that they are influenced by certain expectations when they are trying to diagnose diseases. Doctors may choose a plausible explanation to explain certain symptoms similarly to how some of the participants in this study chose a plausible explanation when an improbable change was presented, For example, doctors may be influenced by recent or common diagnoses, While it is likely that the expectations of a doctor often help them correctly diagnose a patients' symptoms, their expectations can also mislead them, which could result in an incorrect diagnosis. Therefore, it is important that doctors are aware that their expectations may affect a diagnosis and that they consider many possible explanations of the symptoms.

The results of this study also have implications for future studies involving change blindness. While many change blindness studies take into account the size, location, and importance of changes, there are very few that take into consideration that probable and improbable changes may be detected differently. The findings from this study suggest that this may be especially important for research involving incidental change blindness. If researchers do not control for the probability of a change occurring then it is possible that it would affect the results of their study. For example, if a change blindness studies involves two conditions but one of these conditions has more probable changes than improbable changes then the results from the study may be impacted. In order to ensure that this does not occur it may be necessary for change blindness researchers to have an equal amount of probable and improbable changes in each condition so that the differences in performance can be attributed to different conditions and not the change probability effect.

This research creates several questions that should be addressed by future research. Future research on the change probability effect to use image sets other than the ones used in Beck et al. (2004) and Beck et al. (2007b). Different images should be used to ensure that there are no confounding factors that may have influenced the results.

Another issue that should be investigated is whether testing large groups of participants at once can affect change detection performance. The results from this study suggest that visual angle of the participant may have affected change detection performance and further research is needed to investigate if the location of the change played a role in this difference in performance.

Conclusion

The research presented here suggests that the probability of a change occurring can influence change detection. Specifically, this research suggests that observers who are not actively looking for changes are more likely to detect improbable changes than probable changes. This finding is not supported by previous research done on the change probability effect (Beck et al. 2004; Beck et al. 2007b). The findings from this study also suggest that observers may choose a likely explanation of a change if they do not have a detailed representation of the prechange scene. This results of this study can be applied to real world situations and also have implications for future research on change blindness.

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